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APS NEWS

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MEETINGS

Physicists—Jolted by Surprising Mass of Subatomic Particle—Share Discovery at APS April Meeting

BY SOPHIA CHEN

On April 7, researchers reported in *Science* that the fundamental particle known as the W boson was 0.1 percent more massive than expected, a result that has shaken the physics world. Just two days later, these researchers brought their findings to the APS April Meeting.

The discovery could at last reveal how the Standard Model, the framework that physicists have used since the 1970s to understand the basic forces of the universe, is incomplete. As one BBC headline read, "Shock result in particle experiment could spark physics revolution."

Instead of the predicted mass of 80,357 million electron volts, or MeV, the particle weighed 80,433.5 MeV—about 85 times the mass of a proton. The new measurement differs from the Standard Model prediction by "seven sigma"—seven times the measurement's margin of error. This means that the chance the new measurement is a statistical fluctuation "is much less than a part in a billion," said Ashutosh Kotwal of Duke University, who led the new analysis as a member of the Collider Detector at Fermilab (CDF), an international collaboration of some 400 physicists.

The now defunct Tevatron particle accelerator at Fermilab in Illinois, where physicists gathered the data that led to surprising findings about the W boson—findings published in Science on April 7, 2022, and presented at the APS April Meeting a few days later. CREDIT: STEVE KRAVE, FLICKR / CC BY-NC-SA 2.0

The result came two days before the 2022 APS April Meeting in New York City, and meeting organizers

SUBATOMIC CONTINUED ON PAGE 7

JOURNALS

APS's Energy Research Journal, PRX Energy, Publishes its First Issue

BY DAVID BARNSTONE

The newest member of the *Physical Review* family published its first papers on April 7. A highly selective, fully open access journal, PRX Energy provides a forum to facilitate advances in basic and applied energy science.

"The physics community has long been central to energy science," says APS Editor in Chief Michael Thoennessen. "But collaboration across traditional boundaries is now critical, as researchers and stakeholders from diverse disciplines, sectors, and regions focus their efforts on achieving a sustainable energy future."

In their first editorial, Lead Editor David Scanlon and Managing Editor Jacilynn Otero write: "PRX Energy unites researchers from a range of disciplines that span chemistry, biology, materials, environmental studies, engineering and beyond...so scientists can work together globally to move even more effectively toward the discoveries that enable us to more efficiently harness, transform, and store energy and develop innovative technologies."

Crystals of perovskite, a mineral used in solar panels — and the subject of two *PRX Energy* articles.

PRX ENERGY CONTINUED ON PAGE 7

INTERNATIONAL

APS Responds to the Crisis in Ukraine

BY DAVID BARNSTONE

As Russia continues its brutal assault on Ukraine, APS reaffirms its long-held commitment to international science and human rights.

"Our goals as APS are to support the affected physicists, to foster physicist-to-physicist engagement, and direct sanctions only toward institutions," CEO Jonathan Bagger told attendees of a special plenary session at the recent APS April Meeting. Any sanctions would be proposed by the Committee on International Scientific Affairs and approved by the Board of Directors or its Executive Committee.

In the days following the February 24 invasion, APS condemned Russia's unprovoked aggression toward its sovereign neighbor and decried military operations upon or near nuclear facilities such as the Zaporizhzhia power plant.

The Kharkiv Institute of Physics and Technology (KIPT), a Ukrainian physics institute, in a photo taken last year. The institute was damaged by Russian shelling in March, according to the state nuclear inspectorate.

Now, APS is working closely with the US National Academies of Sciences and its Ukrainian counterpart to secure short-term appointments for scholars

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DIVERSITY

Q&A with Michael Ramsey-Musolf, Advocate for LGBTQ+ Inclusion in Physics

BY RACHEL BERKOWITZ

Michael Ramsey-Musolf's challenging experiences as an out gay physicist started in the 1980s and led him to become a firm advocate for sexual and gender minorities in the academic world.

Ramsey-Musolf's first encounter with physics came through a high school course. In that class, he says, a fantastic teacher turned him from hating science to enjoying quantum mechanics and special relativity. The experience was so transforming that he decided to study physics and math in college.

Ramsey-Musolf obtained his bachelor's degree from Pomona College, California, in 1984 and then went on to earn a PhD in theoretical particle and nuclear physics at Princeton University. It was there, in the middle of the AIDS epidemic, that he came out as being gay to family, friends, and colleagues. Motivated by the desire to help economically disadvantaged youth, he also began studying to become an Episcopal priest. He was ordained in 1994—the year he also became an assistant professor. Now, Ramsey-Musolf holds professorships at the University of Massachusetts, Amherst, and at Shanghai Jiao Tong University, China, where he is trying to uncover why the Universe has more matter than antimatter. He is also helping to build an academic environment that's inclusive to LGBTQ+ physicists. *Physics* spoke to Ramsey-Musolf to learn about what drives him to advocate for the inclusivity of sexual and gender minorities in physics.

All interviews are edited for brevity and clarity.

What compelled you to start advocating for increased diversity and inclusion in physics?

My first faculty position was at Old Dominion University in southern Virginia, where I saw racism up close and personal. Southern Virginia, being a very conservative place, was also a tough environment in which to be openly gay, so I moved, eventually ending up at the University of Connecticut.

I had a very difficult experience with harassment in Connecticut that impacted my mental and physical health. That experience politicized me and led me to be more outspoken about LGBTQ+ issues. I then moved to the California Institute of Techology, which felt to me like a nirvana for both science and inclusivity. It was a place where my husband and I were welcomed and loved. However, the funding for my position was not secure, so I had to move again.

At the University of Wisconsin, where I went next, I had supportive colleagues, but I still experienced discriminatory treatment that distracted me from science and came with high legal expenses. It was because of these experiences that I decided to start being more open about discussing sexual and gender identity issues. But the real turning point for me in taking an active advocacy role was the 2012 APS March Meeting.

Michael Ramsey-Musolf

How so?

I participated in a panel discussion on the issues faced by sexual and gender minorities in physics. The session was organized by Elena Long, a transgender physicist at the University of New Hampshire. When I was a student Princeton, Elena had heard me give another scientific talk and had noticed the rainbow flag that I had put on my slides to identify myself as LGBTQ+.

The people in the session that Elena arranged included others who—along with Elena—had

Q&A CONTINUED ON PAGE 6

INDUSTRIAL AFFAIRS

Need for Speed? Consider a Career in Motorsports Racing

BY DANIEL PISANO

Are you a physicist intrigued by fast cars? If so, consider a career in motorsports racing. Maybe you yearn to design a race car that barrels at a mind-boggling clip around the Daytona or Talladega speedways. Perhaps you're curious how engines work, or you want to learn about the mechanics of keeping drivers safe as they fly around tracks.

An F1 race car in action.

Diandra Leslie-Pelecky, who earned her PhD in condensed matter physics, spent two seasons with Roush Fenway Keselowski Racing in North Carolina, learning about fast cars. She left wanting to teach people about the physics behind race cars, and what makes them fast but safe—and with her new book, *The Physics of NASCAR: The Science Behind the Speed*, she does just that.

In her book, Leslie-Pelecky notes that all cars in a NASCAR race are identical, except for the hood, roof, and trunk lid. From the drivetrain to the suspension to the shim under the right front shock absorber, each is built to exacting specifications. So why don't the cars finish the race at the same time?

To answer this question, Leslie-Pelecky brings her physics know-how to the table. The car's drag, she explains, can be influenced by the car's roof and paint finish, making some cars faster than others. And while NASCAR specifies a roof shape using templates, skilled workers have enough wiggle room to manipulate the degree of curvature in the sheet metal. Even more strange, "slippery" paint—paint that helps air flow over the car with little drag—can, along with various finishes and clear protective coatings, make a car faster, sometimes by 0.1 second per lap. In a 500-lap race like the Daytona, this can add up to nearly a minute lead at the finish line.

And where physics is involved, there are usually career paths for physicists. Motorsport racing is no exception.

Consider Formula 1 (F1) racing. Unlike in NASCAR, F1 tracks vary wildly, and F1 cars can reach speeds of 200 mph—40 mph faster than NASCAR permits.

At the University of British Columbia (UBC), Andre Marziali, Director of Engineering Physics and Professor of Physics and Astronomy, leads a program on the physics of racing. The program has helped kickstart fascinating careers for students.

Hillary Cheng, one of Marziali's former students and now an aerodynamicist for the F1 group at Mercedes-Benz, jumped into the world of racing during her first year at UBC.

"I joined the university's Formula SAE [student design] team, where I contributed to the design, build, and testing of an open-wheeled race car," she explained. After that, she said, she was "hooked."

"It was my first glimpse into how much engineering goes into designing a race car and how complex and challenging it can be," she said. Cheng also had the opportunity to intern at three companies, working on projects relevant to her future career at Mercedes.

If you decide to pursue a career in motorsports, you probably won't have to compromise on pay. Motorsports companies want to hire the best and brightest, so they'll offer premium salaries, especially for candidates who can master motorsports tool kits: Programs that calculate drag, hardware that measures flow, and wind tunnels to test cars.

So, if you have a passion for physics and a need for speed, consider motorsports racing. You won't have a slow day.

To learn more about careers in motorsports, keep an eye out for postings on the websites of motorsports racing companies. APS also offers job fairs and job postings, as well as a mentoring program that can help you connect with someone experienced in the field. And visit the APS Careers in Physics webpage at www.aps.org/careers/ to learn about a broad range of careers for physicists.

Daniel Pisano is APS Director of Industrial Engagement.

THIS MONTH IN

Physics History

May 24, 1686: Daniel Gabriel Fahrenheit and the Birth of Precision Thermometry

BY ABIGAIL DOVE

If you start your day by checking the temperature outside, you regularly rely on precision thermometry.

Indeed, it's difficult to imagine a world before temperature could be precisely measured. Precision thermometry lets us cook our food, heat our homes, and detect fevers, all with pinpoint accuracy—and as a society, we use precision thermometry to understand the climate, optimize industrial processes, study thermodynamics, and so much more.

We owe this in large part to Fahrenheit—not the temperature scale, but the man after whom it is named. His name is ubiquitous, but his story is little-known and surprisingly dramatic.

Daniel Gabriel Fahrenheit was born on May 24, 1686, to a well-off mercantile family in Danzig (now Gdańsk), Poland. In 1701, tragedy struck when he lost both his parents to a bizarre and terrible accident: They unwittingly ate poisonous mushrooms.

The orphaned 15-year-old Fahrenheit was taken in by guardians and placed as an apprentice bookkeeper to a merchant in Amsterdam. Though bright, he spent his time diving into newfound passions—physics, mathematics, and, fatefully, glassblowing—instead of bookkeeping.

Fahrenheit became fascinated with thermometers when the Florentine thermometer, invented in Italy decades earlier, began circulating in Amsterdam. The Florentine thermometer—a glass tube with an alcohol-filled bulb connected to a closed stem—was the first thermometer based on a liquid's expansion and contraction, independent of barometric pressure. The instrument was a leap forward in terms of functionality, but suffered from a major design flaw: No two instruments registered the same temperature, because there was no standard way to calibrate thermometers. People instead set their own reference points for the high and low temperatures of these early thermometers, ranging from the point at which butter melts or coals burn, to the warmest or coldest days of the year in the city where a particular instrument was made.

The teenage Fahrenheit, to his guardians' irritation, threw himself into the challenge of developing a precision thermometer that would be reliable everywhere—and he needed money to do it. His late parents had left him a small inheritance, but he couldn't access the funds until he turned 24. So when his apprenticeship ended, he borrowed money to fund his experiments and quickly fell into debt.

His guardians, legally responsible for this debt, were enraged. They plotted Fahrenheit's arrest and deportation to present-day Indonesia, where he would work as a seafaring laborer for the Dutch East India Company until he repaid them.

Gabriel Daniel Fahrenheit, inventor of the mercury thermometer and the Fahrenheit temperature scale.

But when the arrest warrant was handed down, Fahrenheit was nowhere to be found: Unfortunately for them but fortunately for physics, he had fled the country.

Fahrenheit passed through Germany, Denmark, Sweden, and Poland while on the run from the Dutch police. In 1710, he turned 24 and settled his debts, but he stayed on the move, brushing shoulders with natural science luminaries, learning new glassblowing techniques, and dispatching ever-improving versions of his thermometers across Europe.

Fahrenheit toiled for years to perfect a reliable, standardized thermometer. He caught a major break when he started experimenting with instruments containing mercury instead of alcohol. Mercury has a much higher boiling point than alcohol and can therefore expand the range of measurable temperatures. And unlike alcohol, mercury doesn't wet the walls of glass tubes, enabling much more accurate readings.

Armed with this insight and deep skills in instrument-making, Fahrenheit forged ahead. In 1714, at the age of 28, he achieved his goal: developing a pair of thermometers that gave the same temperature reading.

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Contributing Correspondents . . .Sophia Chen, Abigail Dove, Daniel Garisto, and David Voss
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MEETINGS

Molecular Machines Make Waves at APS March Meeting

BY SOPHIA CHEN

The human body is full of tiny machines.

No, this isn't a conspiracy theory: Your cells contain countless proteins that help you convert food, or chemical fuel, into motion. When your heart muscle contracts or your chromosomes pull apart during cell division, these molecular machines are hard at work. This year's APS March Meeting featured three sessions on such machines, including those that occur naturally and those designed by humans.

"Molecular machines" convert chemical energy into mechanical work and range in size from nanometers to hundreds of nanometers. Most naturally occurring molecular machines consist of proteins. These include myosin, which binds to muscle filaments to cause contraction, and kinesin, which shuttles molecules around cells in a walk-like motion. Many of these machines are also extremely efficient. The enzyme ATP synthase, for example, converts nearly 100 percent of free energy into mechanical work to create ATP, a molecule that provides energy to cells.

Research of these machines has taken off since the 1990s, with the rise of single-molecule manipulation and imaging techniques, says Nancy Forde of Simon Fraser University in Canada. Their study could reveal how cells interact with each other, a vital step toward understanding biological processes.

Some researchers, seeking to apply this research, have begun engineering tiny systems that use or are inspired by naturally occurring molecular machines. Recently, Ken'ya Furuta, of Japan's National Institute of Information and Communications Technology, replaced the "feet" of the protein dynein so that it could carry its cargo along a strand of DNA, instead of along the microtubule structures

An illustration of E. coli bacteria, with tail-like flagella visible. At the 2022 APS March Meeting, Jasmine Nirody discussed her research on the E. coli "flagellar motor," an example of a tiny "molecular machine."

CREDIT: KATERYNA_KON, ADOBE STOCK

MACHINES CONTINUED ON PAGE 6

MEMBERSHIP UNITS

In Ohio, Michigan, and Indiana, Physicists Find a Home in One of APS's Oldest Geographical Sections

BY ABIGAIL DOVE

The Eastern Great Lakes Section (EGLS) serves APS members—nearly 1,500 of them—in Ohio, Michigan, and eastern Indiana.

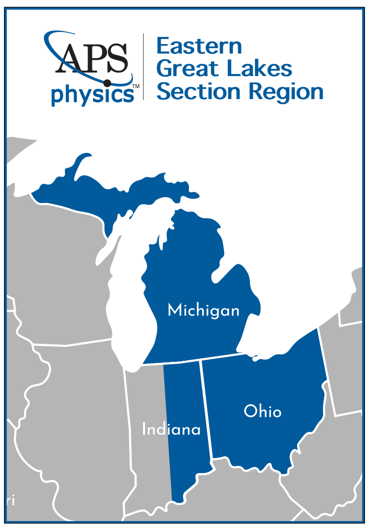
Geographical sections are vital to APS. Membership in a geographical section, said former EGLS chair Cynthia Aku-Leh, can foster collaborations "in your own neighborhood"—between regional laboratories, companies, and schools. And in contrast to discipline-centered subgroups, like divisions, topical groups, and forums, geographical sections offer members opportunities to learn about research at nearby institutions, exposing members to areas of physics outside of their fields.

APS's 10 geographical sections stretch from coast to coast, and EGLS is one of the oldest, founded in 1938 as the Ohio Section. It was renamed in 2006 and again in 2021, when the APS Council settled on its current and final name. "The new name now encompasses the regions that we actually serve," said Aku-Leh, who led the renaming process and lives in Michigan herself.

EGLS holds semi-annual meetings, one in March or April and one in October. Each meeting typically draws 100 to 150 participants and features a slate of talks by leaders in different fields, along with presentations and a poster session.

For many EGLS members, these meetings feel cozy, a refreshing change of pace compared to large international conferences. "It's heartwarming in a sense to see what other people in the region are doing," said Chair-Elect Bhujyo Bhattacharya of Lawrence Technological University. And because travel costs to regional meetings tend to be lower, EGLS meetings are accessible to a wider range of participants. To this end, the executive committee tries to change the meeting location from year to year, choosing host institutions in different areas in the region to encourage participation.

EGLS's 2022 Spring Meeting at Youngstown State University in eastern Ohio was the section's first in-person gathering since the start of the pandemic. The meeting, whose theme was "Pathway to New Physics," featured talks on topics ranging from quantum computing to gravitational waves, as well as a special session on decarbonization in transportation.



Planning is underway for EGLS's Fall Meeting, which will take place on October 21 and 22 at Lawrence Technological University in Southfield, Michigan.

EGLS encourages undergraduate and graduate students—who make up 35% of the section's ranks—to participate in its semi-annual meetings. These meetings enable students to present their research, often for the first time. And the wide range of fields represented at the EGLS meetings, said Bhattacharya, can help students learn to tailor their talks to a broad audience—a vital skill.

EGLS meetings also give students a chance to learn about new areas of physics and even career development. "We organize sessions about professional development and diversity, and we invite graduate schools to come and talk about their programs," said outgoing chair Jay Mathews, a professor at the University of Dayton in Ohio.

Niklas Manz, EGLS's incoming chair, said that the executive committee will continue to build the section into a bustling home for regional physicists. So far, so good, but Aku-Leh acknowledges that the section would benefit from more involvement from physicists working in industry. "We already have a nice, diverse background of physics topics represented at EGLS, but we can do better when it comes to diversity in the places where physicists work," she said.

Still, EGLS stands out as a lively and welcoming geographical section, offering members community, professional development, and learning opportunities. "Being a member helps to support physics in the region," said Mathews, "especially our students, who are the next-generation scientists."

Visit engage.aps.org/egls/home to learn more about the EGLS and ltu.edu/arts_sciences/egls.asp to learn more about EGLS's Fall Meeting.

Abigail Dove is a freelance writer in Stockholm, Sweden.

GOVERNMENT AFFAIRS

For the 2022 APS Congressional Science Fellow, Science and Diversity Are Partners for the Common Good

BY TAWANDA W. JOHNSON

With a combined passion for diversity, equity, and inclusion (DEI) and scientific inquiry, Thomas Plumb-Reyes, the 2022 APS Congressional Science Fellow, is poised to make a positive impact on Capitol Hill.

"I'm deeply honored to be selected," said Plumb-Reyes. "I'm excited to meet and learn from other fellows and alumni with diverse backgrounds and ideas."

APS sponsors the fellowship under the umbrella of the American Association for the Advancement of Science (AAAS) Science & Technology Fellowships to make individuals with scientific knowledge and skills available to members of Congress, few of whom have technical backgrounds. In turn, the program enables scientists to broaden their experience through direct involvement with the policymaking process.

Fellows work directly with congressional leaders and staff for a year, usually from September to August. Fellows complete a two-week orientation in Washington, DC, interview on Capitol Hill, and then choose a congressional office or committee to serve.

Plumb-Reyes earned a PhD in applied physics from Harvard University and brings a wealth of experience, from teaching science and gender equity classes to co-establishing organizations that help marginalized students feel welcome in STEM.

"He has the perfect combination of communication, problem-solving and leadership skills, and a strong motivation to address societal problems through education and science policy," wrote Eric Mazur, Academic Dean and Professor in the School of Engineering and Applied Sciences at Harvard, in a letter of support for Plumb-Reyes.

Thomas Plumb-Reyes

Sarah S. Richardson, Professor of the History of Science and Studies of Women, Gender, and Sexuality, said Plumb-Reyes was an excellent student and teacher. "My engagement with Thomas shows his willingness to stretch himself intellectually and leave his comfort zone in order to learn new things," she wrote.

After his fellowship, Plumb-Reyes may seek a career that lets him shape data-driven policies, ensuring that they reflect the perspectives of stakeholders likely to be impacted by these policies.

Consider artificial intelligence, Plumb-Reyes said. AI could transform human decision-making—but if it's used recklessly, it could become a "technological cover-up" for existing bias and discrimination. "Machine-learning algorithms and facial recognition tools could be used to direct healthcare, identify criminal suspects, and inform bail, parole and sentencing determinations," he explained. But if these tools are created and used uncritically, they could reinforce discrimination that already exists, "with a sheen of scientific or technological objectivity."

FELLOW CONTINUED ON PAGE 6

UKRAINE CONTINUED FROM PAGE 1

affected by the invasion. APS is also providing membership and publications assistance to physicists impacted by the conflict, so they can remain connected to the global physics community, participate in the Society's activities, and access and publish in APS journals. The *Physical Review* journals continue to base editorial decisions on existing criteria and welcome submissions from authors of all nationalities.

"Our goals as APS are to support the affected physicists, to foster physicist-to-physicist engagement, and direct sanctions only toward institutions." -- APS CEO Jonathan Bagger, on the crisis in Ukraine

During the April Meeting session, George Gamota, a Ukrainian-American physicist and international science and technology consultant, explained that APS's support of Ukrainian scientists dates back to the collapse of the USSR, when the Society created an "emergency aid program" (EAP) to provide funding to former Soviet scientists to continue their research (see *APS News* April 2015, Ukrainian Scientists Need Our Help).

"To a large degree, American scientific organizations were slow to react [to the breakup of the Soviet Union]. Except for the American Physical Society," said Gamota, who as a young child fled the Soviets in his native Ukraine soon after World War II ended. His family settled in the United States.

Funded by donations from APS members, the Soros Foundation, and APS's own resources, the EAP provided grants to young scientists, supported the recently established Ukrainian Physical Society, and organized summer conferences in Ukraine with visiting American scientists.

Soon after the Soviet Union's collapse and APS's launch of the EAP, Gamota returned to Ukraine for the first time since he was a child. "What I found...was a country that was jubilant about being free and independent. I did not know what to expect. But I can tell you that I was exuberant." He was the first American to visit some cities in Ukraine.

In 2015, following Russia's unlawful annexation of Crimea and the formation of Russia-backed separatist states in the Donbas, APS again stepped up to support physicists displaced by the conflict.

"Today the whole country is being attacked," said Gamota. "Its very existence is being questioned by an aggressor who does not even call it a war but a 'special military operation'..."

The APS response to the crisis in Ukraine is guided by the Society's mission and values, as well as its response to past conflicts. In 2002, for example, APS rejected calls to boycott Israeli scientists in response to a conflict in the Middle East, writing in a statement, "The APS strongly opposes attempts to isolate any scientific community." In 1980, APS President Herman Feshbach similarly argued against boycotting Soviet physicists following the exile of Andrei Sakharov. These positions are consistent with the APS Statement on the International Nature of Science and International Scientific Cooperation, which notes that international collaborations promote peace, advance science, and benefit the whole of humanity.

Above all, said Gamota, the priority should be the safety and security of the Ukrainian people and their homeland. "Ukrainian scientists who remain in Ukraine are making molotov cocktails and are not worried about the research they would like to pursue unless it can help the war effort, very much like American scientists during World War II," he said.

For more information about APS's response to the Russian invasion of Ukraine, please visit https://go.aps.org/3KnYi5Q or join the Engage Online Discussion Community at https://go.aps.org/3NQJTOe.

David Barnstone is APS Head of Public Relations.

CAREERS

Beyond Academia, Physics Grads Find Diverse Careers

BY TAWANDA W. JOHNSON

When you earn a degree in physics, do you have to become a professor?

The answer is no. In fact, more than half of people with a bachelor's, master's, or PhD degree in physics will work in private-sector jobs, according to the American Institute of Physics (AIP). But the academia myth persists, in part because students struggle to learn about careers in industry and beyond.

APS is working to change this. During the 2022 March Meeting, the Careers Panel Lunch event sought to expose students to diverse, non-academic careers. The panel featured physicists from IBM, Merck, BAE Systems, and UCLA's Quantum Biology Tech Laboratory.

"It hasn't always been easy to seek education about industry opportunities or non-academic career development in general," said Nia Burrell, a PhD student in physics at Northwestern University who attended the event. "I think it's really important for physicists to be reminded that there's so much versatility that comes with our degrees."

Biswajit Datta, a postdoctoral student at the City College of New York, also found the panel helpful. Companies should offer students more internships, he said, to "help students easily learn about industry opportunities [and] be more willing to come out of the academic stereotype that they're only successful if they can become a professor." Datta also noted the benefit of the APS industry mentoring (IMPact) program. "Being able to talk and receive guidance from people who are currently in industry is very valuable," he said.

APS members learn about diverse job opportunities during the Careers Panel Lunch held at the 2022 March Meeting.

Crystal Bailey, Head of Career Programs at APS and moderator for the careers panel, emphasized the importance of industry careers. "Going into industry is a common pathway, and it's incumbent on those who mentor students to let them know that industry careers are rewarding," she said.

If physics graduates are interested in industry careers, Bailey added, then faculty should commit to helping them succeed—and APS can offer support. "APS is doing a lot to help students prepare for careers in industry, and we are here to provide resources to help educators mentor students for non-academic careers," she said. APS supports a mentor program and sponsors webinars, job fairs, and career guides, efforts intended to inform members about diverse career options and emphasize the value of physicists' skills in non-academic settings.

Graduates must also master non-technical skills in addition to technical ones. "The physics community places a lot of emphasis on learning data analysis and using technical equipment," said Bailey," but physics graduates also need

CAREERS CONTINUED ON PAGE 7

FYI: SCIENCE POLICY NEWS FROM AIP

Biden Repeats Bid to Boost Science Budgets

BY MITCH AMBROSE

President Biden's budget request for fiscal year 2023 seeks increased funding across the board for non-defense science agencies, with an emphasis on those connected to his priorities in climate change mitigation, clean energy R&D, manufacturing, and technology. He is also seeking $5 billion for the new Advanced Research Projects Agency for Health, which was established through the final appropriations legislation for fiscal year 2022 with an initial budget of $1 billion.

The request sets the stage for the House and Senate to advance their own spending legislation, which is apt to depart significantly from Biden's request. In its appropriation for fiscal year 2022, Congress significantly scaled back his proposals to boost funding for non-defense science agencies and reversed cuts he proposed to defense research programs following bipartisan negotiations.

With its new request, the administration is trying again to secure major budget increases for agencies such as the National Science Foundation, National Institutes of Standards and Technology, and the Department of Energy's Office of Energy Efficiency and Renewable Energy. Science programs that do not address administration priorities would receive smaller increases or even slight cuts under the request, and early-stage research programs at the Department of Defense would be pared back.

The administration proposes increasing NSF's budget nearly 20% to $10.5 billion, similar to the amount sought last year. Although Congress did greenlight the agency's proposed Directorate for Technology, Innovation, and Partnerships (TIP), it ultimately only provided NSF a 4% topline budget increase for fiscal year 2022, giving it little room to start new activities.

The administration now requests $880 million for the TIP directorate, of which $200 million would go to creating "Regional Innovation Engines" across the country, with the mandate to "catalyze new business and economic growth in those regions of America that have not fully participated in the technology boom of the past several decades." Among NSF's existing research directorates, proposed increases range from 10% over fiscal year 2021 levels for the Mathematical and Physical Sciences Directorate to around 20% each for

FYI SCIENCE POLICY NEWS FROM AIP

its Geosciences, Engineering, and Biological Sciences Directorates.

The DOE Office of Science budget would increase 4% to $7.8 billion, building on the 6% increase just approved by Congress. Within the office, the Biological and Environmental Research program budget would increase 11%, in part to fund a "virtual" national laboratory dedicated to climate and a newly established climate modeling program focused on urban environments. Increases for other programs would range from 5% for Basic Energy Sciences to only 1% for Fusion Energy Sciences, despite pending congressional proposals to rapidly expand programs across the Office of Science.

There are, though, some new activities planned across Office of Science programs, including three new initiatives focused respectively

FYI CONTINUED ON PAGE 6

FUNDING

With Private Funding, Program Helps Professors Teach Cutting-Edge Experiments

BY DAVID VOSS

Even where offered, undergraduate physics typically labs rely on dusty, centuries-old experiments to teach students. But since 2010, the Advanced Laboratory Physics Association (ALPhA) has mentored physics faculty in its Immersion program, teaching cutting-edge experiments that professors can take back to classrooms. Now, with a new private endowment, the program can grow and thrive for years to come.

Classic experiments, like the Millikan Oil Drop or the Cavendish Torsion Balance, have been making the rounds in undergraduate classrooms for decades. They're staples, but they often don't take advantage of the incredible advances made in physics experimentation in recent years.

ALPhA aims to solve this. In its multi-day Immersions program, faculty members learn, and learn to teach, modern lab experiments using the latest gear, from holography and optical interferometry to high Tc superconductivity and graphene—all alongside experienced mentors.

"For someone to learn to teach an experiment takes a lot of time, so the Immersions program is intended to help with that," said Lowell McCann, physics professor at the University of Wisconsin-River Falls and Immersions program organizer. "We want people at the end of two and a half days to have the confidence to set up the experiment and be able to teach it."

So far, the program has been a success: 630 participants have enrolled since its inception (in each course, half the participants are repeat enrollees and half are new).

Physics faculty attend ALPhA Immersions sessions to learn from mentors about modern instructional lab experiments and how to teach them.
CREDIT: LOWELL MCCANN

"That works out to 281 institutions of higher learning," said McCann, "which means we're impacting something like 35% of the physics departments in the United States." Better still, nearly 40% of surveyed participants say they implemented lab experiments based on the program within a year and a half of attending it. Now, some of the program courses have waiting lists.

ALPhA Immersions was first funded by the National Science Foundation, but those coffers are drying up. To fill the gap, the Jonathan Reichert Foundation—also an early supporter of the program—found sponsors for an endowment that would support the program in perpetuity.

The Foundation met its funding target in August 2021, with a $200,000 gift from the Synopsys Corporation in California, a $200,000 match from the Reichert Foundation, a $51,000 personal contribution from Jonathan Reichert (Teachspin Inc.), and $69,000 in other contributions. Today, with

FUNDING CONTINUED ON PAGE 6

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But what about the numbers on the Fahrenheit temperature scale?

Fahrenheit came up with those, too—and while the points on that scale may seem random, they were logical for the standards of the time. The decimal system was not widely used yet, so neatly divisible numbers were considered the most elegant, since they avoided the need for fractions.

So, Fahrenheit calibrated his temperature scale between 0 and 96. Conveniently, 96 was a highly composite number divisible by 2, 3, 4, 6, 8, 12, and more. He defined 0°F as the freezing temperature of a brine solution made from equal parts water, salt, and ice, and 96°F as the temperature of the human body, which he measured by placing the thermometer under his arm (This would later prove slightly inaccurate: Human body temperature is 98.6°F). In this scheme, water freezes at 32°F (perfectly one-third of the way between 0 and 96) and boils at 212°F (180 degrees—another highly composite number—from water's freezing point).

Initially, the Fahrenheit scale was widely adopted, a trend driven by enthusiasm in England, where Fahrenheit had developed a high profile as a member of the British Royal Society. And as the British empire expanded, the Fahrenheit scale—along with metrics like miles, pounds, feet, and ounces—would spread, too, dominating the Anglophone world and much of the globe in the 18th and 19th centuries.

But in 1742, nearly three decades after Fahrenheit's innovation—and just six years after his death at age 50 from what may have been mercury poisoning—Swedish astronomer Anders Celsius developed a more intuitive (by today's standards) temperature scale set between 0 and 100. The original Celsius scale used 0°C as the water's boiling point at sea level and 100°C as its freezing point, purportedly to avoid dealing with negative-number readings, an all-too-relevant concern during harsh Swedish winters (the scale was inverted to its present form after Celsius' death).

After the French Revolution, France quickly integrated the Celsius scale into its burgeoning metric system, which it had developed to unify the country under standardized units of measurement. By the mid-1800s, much of Europe had fully adopted the metric system. In the mid-1990s the International System of Units was formalized (see *APS News* May 2019), and most countries still using the Fahrenheit scale and other imperial units opted for "metrication" (see *APS News* May 2019).

But despite the ubiquity of the metric system worldwide, the United States famously remains an outlier, one of only three countries in the world to use the Fahrenheit scale and other imperial units (and the other two, Liberia and Myanmar, have already announced their intentions to switch to the metric system). Despite some efforts to convert to the Celsius scale and other metric units (for a short-lived moment in the 1970s, Congress even established a Metric Board to lay the groundwork), public sentiment in America has sided with Daniel Fahrenheit.

Call it aesthetic preference, a matter of convenience, or gratitude for the pioneer of precision thermometry—300-year-old habits die hard.

Abigail Dove is a freelance writer in Stockholm, Sweden.

Further Reading:

Friend, JN. "The Origin of Fahrenheit's Thermometric Scale," *Nature* 139: 395-398 (1937).

Grigull, U. "Fahrenheit: A Pioneer of Exact Thermometry," *Proceedings of the 8th International Heat Transfer Conference* 1:9-18 (1986).

OBITUARY

Tom Gaisser, 1940-2022

BY DANIEL GARISTO

Tom Gaisser CREDIT: COURTESY OF JULIA GAISSER

Tom Gaisser, a particle physicist who calculated the complexities of cosmic rays, died February 20. He was 81. Gaisser was an American Astronomical Society Fellow and APS Fellow, a spokesperson for the IceCube Neutrino Observatory, and a professor at the University of Delaware. He won accolades throughout his career, including the Humboldt Research Award and the O'Ceallaigh Medal for cosmic ray research.

"If you would think of one person who created the concept of 'particle astrophysics,' it was him," said Francis Halzen, a particle physicist at the University of Wisconsin-Madison. Gaisser's work between the 1970s and 1990s helped unify the newly-dubbed particle astrophysicists, who measured tiny things—photons, neutrinos, and muons—to explore enormous ones—supernovae, neutron stars, and black holes.

Despite his theoretical background, Gaisser valued fieldwork, visiting telescopes from Arizona to Argentina. Gaisser also journeyed to Antarctica to help construct IceCube and its surface array, IceTop. Even after he retired, Gaisser continued to collaborate on IceCube.

"He would get his hands dirty," said Halzen. "He would shovel snow and make sure the photomultipliers were okay. He loved it." In his honor, a federal committee named a 2.8-kilometer ravine in the frozen reaches of eastern Antarctica's Gaisser Valley.

"Tom was basically very modest," said Julia Gaisser, his wife. "It was only when I saw the University of Wisconsin website that I knew that a place in Antarctica had been named after him."

Thomas Korff Gaisser was born in Evansville, Indiana, on March 12, 1940, to Clyde and Valada Gaisser, who owned an equipment business. He attended Wabash College and, in 1962, sailed to England on a Marshall Fellowship. Aboard the ship *Queen Elizabeth*, he met Julia Haig, another Marshall Fellow. The two were at different universities, but Gaisser wrote to Haig asking if she'd like to see some plays in London over the holidays. "After that, we just stayed in touch for the next 60 years," she recalled. They married in 1964 and spent the next few years navigating the two-body problem of dual academic careers—Tom's in physics, Julia's in classics.

After postdoctoral positions at MIT and Cambridge University, Gaisser joined the Bartol Research Institute in 1970, where he remained for the rest of his career (the Institute merged with the University of Delaware). Julia Gaisser took a job as a classics professor at nearby Bryn Mawr.

At Bartol, Gaisser jumped from theoretical physics to cosmic ray research. In the 1970s, he and his colleagues applied particle physics to astronomy, treating the explosive showers generated by cosmic rays like high-energy colliders floating in the atmosphere. Gaisser was adept at calculating the parameters of air showers, computing their antiproton yields and, with Michael Hillas, longitudinal particle density.

In 1978, Gaisser helped organize the Bartol Conference in particle astrophysics. Half the participants were particle physicists who felt at home with acceler-

GAISSER CONTINUED ON PAGE 7

FELLOW CONTINUED FROM PAGE 3

No matter the challenge, Plumb-Reyes said that policy solutions are strongest when they incorporate diverse perspectives. He attributed this view, in part, to his family: His mother, a native Spanish speaker and one-time migrant farmworker, pursued a career in social work in the Sacramento community in which he grew up.

"[She] taught me about the opportunities provided by education and the struggles of being an immigrant, low-income or minority person in this country," said Plumb-Reyes.

And as an advocate for education policies, his mother was sensitive to the needs and experiences of immigrant and low-income communities. "She showed me how policy is enriched by closely involving stakeholders in its development," he said.

Plumb-Reyes brought these lessons to Harvard, where he helped develop a program aimed at helping attendees feel welcomed during the 2017 Northeast meeting of the APS Conference for Undergraduate Women in Physics (CUWiP).

"The other organizers and I felt it was important to center the conversation on groups who may even feel marginalized in a conference like CUWiP," he explained. The workshop, called Supporting Inclusion of Underrepresented Peoples (SPIN UP), took place before the conference and focused on the needs of a smaller group of attendees.

Plumb-Reyes also co-founded the Graduate School of Arts & Sciences' Society of Underrepresented Students in STEM, an affinity group for peers to connect for formal and informal support.

"Our goal was to create a comfortable and empathetic space where students could share their experiences, develop the skills they need, exchange advice, and see themselves represented in the field," he said.

Plumb-Reyes' teaching experience will also serve him well. At Harvard, he taught diverse courses intended for non-majors, from "Applied Physics 50" and "Finding Your Way." For both courses, he said, he "broke down science into understandable lessons and applicable scenarios."

Mark Elsesser, APS Director of Government Affairs, is eager to see Plumb-Reyes succeed.

"Thomas is bringing great experience and a terrific skillset with him to Capitol Hill," Elsesser said. Whichever congressional office Plumb-Reyes serves in, Elsesser added, will be lucky to have him.

Tawanda W. Johnson is APS Senior Public Relations Manager.

Q&A CONTINUED FROM PAGE 1

previously formed a grassroots organization to create more awareness of the experiences of LGBTQ+ physicists. I joined them, and we've since put together a Best Practices Guide for institutions on how to help mitigate the challenges faced by members of the LGBTQ+ physics community.

Can you give some examples?

The Best Practices Guide summarizes five actions that physicists and institutions can take: assess and address the climate, break the silence and invisibility, set the example and expectations, educate and advocate, support and include. Specific examples include training people to be LGBTQ+ allies and making public who those allies are, inviting people to share their pronouns, and providing safe spaces for queer folks to gather on campus. On a bigger scale, institutions can re-weigh the criteria that they use for hiring academic faculty to better account for the obstacles people from minority backgrounds and identities have had to overcome during their career.

Do you have any success stories you can share?

In 2018, Brookhaven National Laboratory (BNL), New York, offered up scholarships for minority postdocs to lecture at the lab. I wanted to nominate a gay, non-white individual. But sexual orientation was not listed in the scholarship criteria. I asked why. That led to a discussion between me and the BNL staff and to a policy change for the scholarships.

Why do you think that the LGBTQ+ community has historically been overlooked in conversations about diversity and inclusion in physics?

The physics community's awareness of discrimination parallels that of society. When I came out in the mid-1980s, I had to worry not just about whether my presence would be "welcomed" but also whether it would even be tolerated. Back then, physicists were talking about increasing the representation of women in physics, but they weren't considering doing the same for LGBTQ+ folks. It wasn't until the 2000s—when countries around the world began to recognize same-sex partnerships and legalize same-sex marriage—that LGBTQ+ folks started being included in physics-diversity conversations.

How have things changed in the last couple of decades?

Today in the US, for example, materials about diversity and inclusion now routinely include sexual and gender minorities. LGBTQ+ folks are also starting to be considered in things like planning of university facilities. For example, in 2018, the University of Massachusetts built gender-neutral bathrooms in the most prominent science building and added signage that points them out. That change sends a broad message to anyone entering the building that we're an inclusive space. There are, however, many places in the world that are much less inclusive and others where being LGBTQ+ is still illegal. We have a way to go.

Any tips for young physicists wanting to help make more inclusive workplaces?

Speak up for what you think is right. Know that allies in our field will listen to you and support you.

Rachel Berkowitz is a Corresponding Editor for Physics based in Vancouver, Canada. This article was reprinted from Physics Magazine and is part of a series on the experiences of LGBTQ+ physicists. See also: Making Physics Inclusive to LGBTQ+ Folks; Life as an LGBTQ+ Physicist; and Wanted: LGBTQ+ Allies. To read the Best Practices Guide mentioned above, visit arxiv.org/abs/1804.08406.

FYI CONTINUED FROM PAGE 4

on building research capacity at minority-serving institutions, achieving "Earthshot" technology maturation goals, and supporting technology-oriented science more broadly.

NIST's budget would increase nearly 20% to $1.5 billion in support of priorities such as quantum information science, artificial intelligence, restarting the agency's research reactor, and addressing a large backlog of deferred maintenance at other agency buildings.

Notably, Congress provided NIST with a nearly 20% budget boost for the current fiscal year but most of the new money is for earmarks, a practice Congress revived after a decade long moratorium. Many of the earmarks are tangential to the agency's mission, the largest of which is a $60 million upgrade to the University of South Alabama College of Medicine in the home state of Senate Appropriations Committee Vice Chair Richard Shelby (R-AL).

Congress will likely begin to unveil its counterproposals to Biden's new budget in late spring or early summer.

Mitch Ambrose is Director of FYI.

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MACHINES CONTINUED FROM PAGE 3

that make up its normal route in cells. Similar artificial machines could eventually be used to deliver drugs to target systems or to control chemical reactions.

Shoichi Toyabe of Tohoku University in Japan presented recent work on ATP synthase, a protein found in the mitochondria of human cells and virtually all other organisms. ATP synthase has two "motors," F0 and F1. F0 drives F1, and F1 catalyzes the synthesis of ATP, rotating 120 degrees to do so.

Toyabe's team was interested in F1. Why and how did the F1 motor preferentially rotate in one direction? To find out, the team placed isolated proteins on a probe, which they rotated using a changing electric field. The team found that ATP synthase has a mechanism that prevents the F1 motor from reversing, which they call "rectification," in analogy with an electric circuit, where a rectifier only allows current to flow in one direction. The work raises the question of whether other proteins also encourage cellular processes to proceed in a certain direction. Eventually, Toyabe hopes to build an artificial machine, inspired by the F1 motor, out of DNA.

Jasmine Nirody, a postdoc with joint appointments at Rockefeller University and Oxford University, presented research on flagella, the hairlike appendages that cells use to propel themselves (picture the single flagellum, or "tail," of a sperm cell). A bacterium's flagellum propels it via rotation, powered by ion gradients between the interior and exterior of the cell.

Research on the flagellum could inform the design of more adaptable artificial molecular machines, according to Nirody. While human-designed motors can usually only function in specific conditions, she says, "the flagellar motor navigates these heterogeneous and unpredictable environments within cells. That aspect is fascinating and something that we can really learn from."

At the 2022 APS March Meeting, Nirody presented a new flagellum model, an update based on detailed cryo-EM images released by researchers in 2020. The new images revealed that the flagellum rotates like a gear, driven by another rotating component.

Nirody's work, like Toyabe's, could help researchers design better molecular machines. "What has evolution done that we haven't figured out how to do?" Nirody says.

Nancy Forde, presenting work led by her graduate student, Chapin Korosec, introduced an artificial molecular machine they had created, dubbed "the lawnmower," the outcome of a 15-year international collaboration between biologists, condensed matter physicists, and nanoscientists. The lawnmower is an artificial, nanoscale spherical bead covered in trypsin, a protein in the digestive system that breaks down other proteins. When the lawnmower is placed on an engineered surface covered in molecules called peptides, it cleaves the peptides, cutting them like grass in a yard. The lawnmower also powers itself, harnessing free energy released from the clipped peptides to continue moving.

The lawnmower's design draws inspiration from the influenza virus, which is also spherical, sticks to cells, and cleaves cell receptors.

While Forde's team could not control the lawnmower's trajectory, they found that the lawnmower moved in a biased direction away from regions it had already mowed. Its average speed reached 60 nanometers per second, which is about the rate that grass grows.

Forde aims to use the underlying architecture of the lawnmower to create other types of molecular machines. They designed the lawnmower to be modular, so researchers can easily change its design—swapping the trypsin for another protein, for example, or changing the size of the quantum dot to tailor it for a specific application.

Eventually, Forde hopes to create molecular machines that can do "what nature has evolved proteins to be able to do," she says. "It gives you this amazing appreciation of what nature has managed to evolve."

Sophia Chen is a writer based in Columbus, Ohio.

FUNDING CONTINUED FROM PAGE 5

funds topping $520,000, the Immersions program can thrive permanently.

The endowment is a relief for Gabe Spalding, professor of physics at Illinois Wesleyan University and vice president of the Foundation. "[There has] been a long, slow decay in the national investment in educational infrastructure," he said. "And there are a number of institutions that just have not valued laboratory instruction. There's this attitude that students will pick it up through research, but there is no replacement for a foundational curriculum." As a result, the Immersions Program offers a vital resource.

The funding is also an example of a successful partnership with industry—in this case, Synopsys. After all, most physics majors will enter the private sector, so companies benefit when education is robust.

"I believe this is a first for the physics community—namely, a privately raised endowment to fund physics education," said APS Fellow Jonathan Reichert, who with his wife has also sponsored the APS Jonathan F. Reichert and Barbara Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction.

Reichert said he knew of successful programs forced to end when NSF funding ran out. Private partnerships, like that of this ALPhA Immersions program, are "a way forward," he said. "This endowment could become a model for future successful education programs."

Additional Information

ALPhA Advanced Laboratories (advlab.org)

Jonathan F. Reichert Foundation (jfreichertfoundation.org)

"Undergraduate labs lag in science and technology," *Physics Today* (April 2017)

David Voss was formerly Editor of APS News.

PRX ENERGY CONTINUED FROM PAGE 1

The first three research articles are summarized below.

A Statistical Snapshot of Europe's Sustainable Energy Market

Wind and solar power promise the possibility of zero-emission power generation. But unlike the burning of fossil fuels, the production of wind and solar power is variable: Some days are calm and windless, and the sun doesn't shine at night. To meet this challenge, energy markets must be able to balance variable output against demand. They will also need to rely on short-term trading—that is, trading electricity by the half-day, hour, or even minute—and integrate supply from small producers.

To better understand fluctuations in price and demand, Chengyuan Han's team analyzed data from the European Power Exchange, called EPEX SPOT, which sets prices for energy products, with varying targets and durations, across a vast Western European market. The researchers found that price fluctuations varied dramatically across hours and days, and according to weather patterns. They suggest that q-Gaussian distributions best fit their data of electricity prices.

Testing for Capacitance in Perovskite Solar Cells

For decades, abundant silicon has been the go-to element used in the production of solar cells, the building blocks of solar panels, but a family of materials called perovskites are quickly catching up. Perovskites' crystal structure makes them appealing for use in high-performance, low-cost solar cells, and perovskite solar cells (PSCs) are now nearly as efficient as their silicon counterparts. To further improve PSCs, researchers need to develop strategies for identifying processes that limit the power output of the cells.

Sandheep Ravishankar's team found that existing methods of analyzing PSCs often mischaracterize the cells' "capacitance"—their ability to capture and store energy in the form of electricity. This challenge arises from particular traits of the PSCs. The researchers developed a new model for improving the quality of capacitance measurements, which can detect defects that reduce the solar cell's efficiency. Using simulations and analytical modeling, they developed guidelines to better assess capacitance, with applications to PSCs and solar cells in general.

A New View on the Optoelectronic Properties of Metal Halide Perovskites

Two-dimensional metal halide perovskites (MHPs) are excellent absorbers of light. But before 2D HDPs can be used in existing devices, like solar cells, researchers will need to be able to fine-tune the material's optoelectronic properties, a task that requires accurate and precise measurement.

Kameron R. Hansen's team investigated these properties by fabricating atom-thin layers of MHPs on an array of gold electrodes. After running experiments on the device, they developed a new method of measurement for band gap and exciton binding energy. The method reduces measurement errors by an order of magnitude, from about 40 meV (typical of today's state-of-the-art approaches) to about 4meV. Such high precision, the authors noted, points to new opportunities to learn how chemical and environmental factors shape the properties of MHPs—and ultimately guide the design of new, highly efficient devices that harvest and/or emit light.

PRX Energy is waiving all article publication charges for manuscripts submitted on or before December 31, 2022. Keep up with the latest research by subscribing to monthly table-of-contents alerts at info.aps.org/journals-emails and following the journal on Twitter at twitter.com/PRX_Energy.

David Barnstone is APS Head of Public Relations.

CAREERS CONTINUED FROM PAGE 4

skills such as leadership, teamwork, and communication."

Panelists also discussed whether a person needs a PhD to be considered a physicist—a topic highlighted during an APS Annual Leadership Meeting session. According to AIP, fewer than one in five graduates with bachelor's degrees in physics will complete a PhD.

More than half of people with a bachelor's, master's, or PhD degree in physics will work in private-sector jobs.

Panelist Audra Macie, a Space Systems Program Engineer Manager II at BAE Systems, pointed out that she held a bachelor's degree and not a PhD in physics, but has had ample opportunity to participate in research.

"We have to confront the myth that in order to be considered a physicist, you have to have a PhD in the field," said Bailey.

Matthew C. Thompson, Director of Systems Engineering at Zap Energy, Inc. and Past Chair of the APS Forum on Industrial & Applied Physics, was thrilled that 150 students attended the panel.

"The demand from physics graduate students and postdocs for information on how to navigate post-academic careers, which the vast majority of them will have, remains as strong as ever," said Thompson.

For Steven Lambert, former Fellow of APS's Industrial Physics Program, the best part of the panel was talking afterward for more than an hour with students. "They asked many probing questions," said Lambert. "This in-person interaction is so important, and it's great practice for essential networking skills."

You can find APS's career resources at impact.aps.org, aps.org/careers, physicsforums.com, prosperousphysicist.com, and *The Effective Resume*, a book by Matthew Thompson.

Tawanda W. Johnson is APS Senior Public Relations Manager.

GAISSER CONTINUED FROM PAGE 5

ators, and half were cosmic ray researchers. Different communities of researchers came together.

Throughout the 1980s, Gaisser fleshed out the possibilities of particle astrophysics. "Tom was one of the first people to take the tools of particle interactions, and to use them to predict what kind of signal you might see from astrophysical objects," said Jamie Holder, Director of the Bartol Institute. In 1985, Gaisser and Todor Stanev managed a tricky, precision calculation of the flux of atmospheric neutrinos from Cygnus X-3, a binary star system. The next year, he and two colleagues, Serap Tilav and Gary Steigman, did some of the first phenomenology of WIMP dark matter.

"These are very hard problems because the information you get from the experiment is very indirect compared to the information you want to get out of it," said Halzen. "You had to work backwards to the top of the atmosphere." Some experimentalists doubted that precise predictions were possible.

But by the late 1980s, underground Cherenkov detectors—repurposed to detect particles like neutrinos—had found an anomaly: Atmospheric neutrino fluxes that Gaisser had predicted didn't match detector measurements. The result eventually led to the discovery of neutrino oscillations.

In 1990, Gaisser published *Cosmic Rays and Particle Astrophysics*. "I would not even call it a book; it's a working instrument," said Elisa Resconi, an experimental physicist on IceCube, who worked with Gaisser on the second edition. Researchers continue to rely on *Cosmic Rays*, said Tilav, because "Tom was really a master of reducing really complex phenomena toward really easily understandable concepts."

Other colleagues remembered Gaisser's conscientiousness. "Tom was an absolute gentleman, who was one of the researchers that was really invested in the success of the people that he mentored or took on," said Nigel Smith, the director of TRIUMF, Canada's national particle accelerator center. Tilav, Gaisser's first graduate student, enjoyed working with him so much that she returned to the University of Delaware. "I feel so orphaned at the moment, because he was always on the theory, I'm on the data part," she said. "I feel like half of me is missing."

"This is a gigantic loss," said Resconi. "We were really shocked when we heard the news."

Gaisser's passions extended beyond physics; he loved chamber music, philosophy, and art, from the Old Masters to modern painters like Wassily Kandinsky and Diego Rivera. In 1977, Julia and Tom Gaisser combined Latin and physics expertise to write a paper, "Partons in Antiquity," which suggested that Ancient Greek atomic theory was analogous to the problem of quark confinement, indicative of "the conflict between the notion of infinite divisibility and the idea of discrete elementary particles as the basic building blocks of the universe."

"Tom was always very proud of that paper," said Julia Gaisser. "I think he was proud of it because it was something we did together."

Daniel Garisto is a freelance writer based in Bellport, New York.

SUBATOMIC CONTINUED FROM PAGE 1

rushed to schedule a session for Kotwal and collaborators. At 7 a.m. on Tuesday, April 12, some 100 bleary-eyed meeting attendees, from graduate students to experts in the field, showed up to listen to the group speak over a Zoom video call projected in a hotel conference room.

"It's such a major result, and it's really great to hear it straight from the horse's mouth," said Glennys Farrar of New York University, who had read the paper before attending.

This discrepancy between measurement and theory may be exactly what physicists wished for. For years, the field has searched for holes in the Standard Model, as it does not account for empirical findings like dark matter and dark energy.

"It's an exciting time," said fourth-year graduate student Kenneth Vetter of the University of California, Berkeley, citing other potential Standard Model-breaking results, such as anomalous B-meson decays. "Maybe we're coming out of the dark ages."

Experts have long predicted that the W boson, which carries the nuclear weak force responsible for radioactive decay, could offer a window into physics beyond the Standard Model. Some theorists think that the particle's mass could hint at the existence of yet-undiscovered particles, such as another Higgs-like particle, according to Kotwal.

CDF spent ten years analyzing its data before publishing the result this April, explained Kotwal. The mass measurement is based on about 4 million W bosons produced in the Tevatron, a now-decommissioned collider at Fermilab in Illinois, between 2002 and 2011. The Tevatron produced W bosons by colliding protons and antiprotons traveling near the speed of light. The collisions produce jets of other particles, including the W bosons, which quickly decayed into other particles.

CDF inferred the W boson mass by measuring the energy and direction of its decay products. To measure the mass so precisely, the researchers relied on cosmic rays—high-energy protons that naturally arrive from space. When cosmic rays hit the atmosphere, they produce showers of fast muons that move in straight lines. CDF used these muons to align parts of their detector to a micron, said Kotwal.

Now, the scrutiny begins. "The detailed questions are going to come out over the next year, as people external to CDF start to dig into this result," said Gordon Watts of the University of Washington, who attended the talk. For Farrar, the result raises questions regarding models of proton innards, known as parton distribution functions, on which the W boson mass measurement relied.

Kotwal is prepared for the feedback. "After eight or nine years of internal scrutiny and checking, at some point you are ready to say, 'let's open the box,'" he told *APS News*.

Sophia Chen is a writer based in Columbus, Ohio.

THE BACK PAGE

Productive Scientific Discourse Demands Respect

BY FRANCES HELLMAN, ROBERT ROSNER, YOUNG-KEE KIM, S. JAMES GATES, JR., DAVID G. SEILER, ROBIN SELINGER, AND JONATHAN A BAGGER

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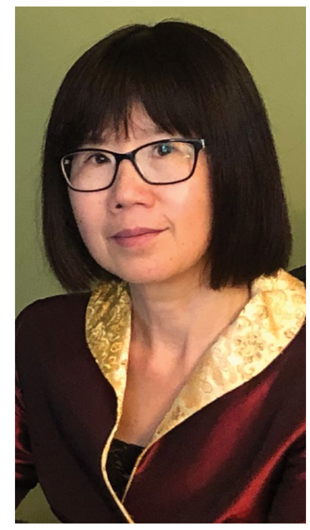

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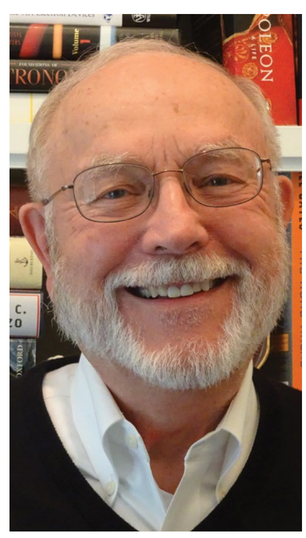

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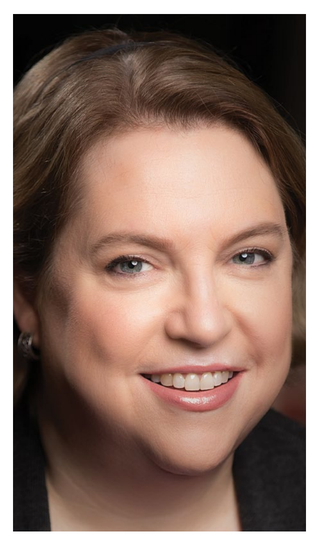

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APS strives to provide a welcoming and inclusive environment for all those engaged in physics. Increasing diversity, equity, and inclusion (DEI) is essential to advancing and diffusing knowledge in an interconnected world and effectively addressing global scientific challenges. Yet these goals are thwarted by routine reports of harassment and intimidation directed at members of our community [1,2].

Many physicists working to address DEI issues are members of the physics education research (PER) community. APS values this branch of physics, as evidenced by policy statement 99.2 [3] and our support of the Topical Group on Physics Education Research. Like other disciplines in physics, PER employs a variety of methodologies, frameworks, and collaborations from and with other disciplines. These approaches are well represented across the breadth of papers published in *Physical Review Physics Education Research* (PRPER).

A recent article published in the journal investigated diversity and inclusion through the lens of Critical Whiteness Studies, a subfield of Critical Race Theory [4]. While we neither endorse nor challenge the paper's findings, we condemn the highly inappropriate and harassing emails and social media responses to the paper, some of which appear to have little basis in the content of the article.

Like all research, physics education research, both in general and related to DEI, invites constructive criticism. Such conversations are critical for advancing knowledge in any scientific field. However, productive discourse requires all participants to exercise intellectual humility and willingness to listen, especially when conversations cross disciplinary boundaries.

As Charles Henderson (Lead Editor, PRPER) and Michael Thoennessen (APS Editor in Chief) make clear in an editorial, “The Physical Review invites constructive and respectful criticism of published articles in the form of Comments. Harassment and intimidation against authors are not acceptable behaviors and have no place in scientific discourse.” [5] Not only are these actions unacceptable, the editors write, but they also violate our standards of ethical conduct.

"Like all research, physics education research, both in general and related to DEI, invites constructive criticism. [...] However, productive discourse requires all participants to exercise intellectual humility and willingness to listen..."

The APS Guidelines on Ethics define harassment as “disrespectful behavior of any kind with the intent or effect of humiliating and controlling another person. It can include verbal and physical interactions, and display or circulation of written materials or images, including those communicated via digital devices, such as interactions via text messaging or social media. Harassment creates an atmosphere in which productive scientific discourse is not possible, and harms the victim as well as the progress of physics.”

The APS Ethics Committee regularly reviews and responds to allegations of harassment and related misconduct. In some cases, these behaviors may lead to the revocation of APS awards, prizes, leadership positions, and/or disqualify candidates from consideration. Individuals who violate the APS Code of Conduct may be excluded from participation in APS meetings.

We encourage the physics community to approach physics education research as they would any field outside their immediate area of expertise: with curiosity, skepticism, and an open mind. Progress in research requires critical examination; ideas and results are often challenged; immediate consensus is not expected. Constructive criticism is a way to support researchers and promote their efforts, but harassment and personal attacks have no place in scientific discourse. We must provide inclusive spaces that empower all individuals to thrive, especially those who are marginalized. Our community must engage meaningfully and substantively with new, often complex, ideas to ensure all people have full and equitable access to physics.

This article was written in consultation with the Executive Committee of the Topical Group on Physics Education Research (GPER).

References

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[3] APS Statement 99.2 Research in Physics Education

[4] *Observing whiteness in introductory physics: A case study*, Amy D. Robertson and W. Tali Hairston, *Phys. Rev. Phys. Educ. Res.* **18**, 010119 (2022)

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